Ecological review of the Koo-Wee-Rup Swamp and associated grasslands

Jeff Yugovic and Sally Mitchell

Biosis Research, PO Box 489, Port Melbourne 3207

Abstract

An understanding of the ecology of the Koo-Wee-Rup Swamp was obtained from historical surveys and soil maps. The probable boundary of the former largest swamp in Victoria was determined. The immense swamp had distinct zones formed by inner and outer swamps: the inner swamp was a permanently inundated reed and rush swamp with emergent sand ridges and possibly with lake-like cells, while the fringing outer swamp was largely paperbark scrub subject to frequent flooding. Grassland and acacia woodland were locally extensive adjacent to the swamp in areas of periodic flooding. The inner swamp boundary was probably flood controlled while the outer boundary was probably fire controlled on the plain and topographically controlled by hills to the east. Rare examples of swamp scrub and grassland remain. (*The Victorian Naturalist* **123** (5), 2006, 323–334)

Introduction

The Koo-Wee-Rup Swamp, also known as the Great Swamp, the Great Marsh and Kuwirap, was the largest swamp in Victoria. Draining and clearing the immense swamp for agriculture was a major undertaking commencing in the 1870s and continuing in stages to the 1960s, imposing hardship on early settlers. It took several attempts over nearly 90 years to drain the swamp, during which time there were at least twelve floods, the last in 1952 (Roberts 1985). The swamp was destroyed without any detailed account of its original condition (Hills 1942) so what is known of its ecology is constructed from fragmentary and often indirect evidence.

The Aboriginal name Kuwirap is said to mean 'blackfish swimming', from kowe = water and wirap or werup = blackfish (Database of Aboriginal Placenames of Victoria 2002). Surveyor William Urquhart (1847) recorded the name of the swamp. His field book states that the Great Swamp was called 'Cowirrip' by the 'Natives'. The name of the swamp is spelt in several ways. Koo-Wee-Rup and Kooweerup are official historical place names. The spelling Koo-Wee-Rup was used for the swamp before and during the time of drainage and is applied here. Koo Wee Rup is now the official place name of the town on the former edge of the swamp.

Kuwirap was effectively impassable and formed part of the boundary between the inland Woiwurrung and the coastal Boonwurrung people. The northern edge was inhabited by the Bulug willam clan, meaning 'swamp dwellers' from buluk = swamp and willam = dwelling place. The southern edge was inhabited by the Yallock balug clan of the Boonwurrung, meaning 'river people' from yallock = river and bulluk = people (Clark 1990, 1996).

In order to understand this unique ecosystem and locate remnant vegetation, historical data and information are used here to map the outer boundary of the swamp. Soil mapping allows a glimpse of the inner swamp. Further analysis is in Yugovic and Mitchell (2004, 2005).

Methods

Copies of early survey plans were obtained from Land Victoria and the State Library of Victoria. Mapping was undertaken using GIS software and the Cardinia Shire Council digital base map of roads and watercourses. Plans were scanned and registered as accurately as possible, using reference points such as creek alignments, land boundaries and, in the case of Urquhart (1847), Mount Ararat and Cannihal Hill. Swamp and grassland boundaries were digitally traced and combined on one composite map.

Map data and information sources were:

Survey map of Urquhart (1847)

Map of the western and northern edge of the swamp and adjacent open plains from Tooradin to Garfield, remarkable detail

with traverse points shown, valuable annotations on vegetation.

Survey map of Foot (1855)
Map of the southern swamp edge from The Inlets to Yallock, shows crown allotments allowing better resolution and registration with the base map, valuable annotations.

Survey map of Callanan (1859)
Map of the northern swamp edge from Cardinia to Pakenham, shows allotments, valuable annotations.

Plan K118 (1866)
Map of the southern swamp edge in the Yallock area, shows allotments, valuable annotations.

Plan L3335 (1866)
Map of the near-coastal swamp edge and The Inlets, shows allotments, valuable annotations.

Plan Rail 84C2 (1873)
Railway survey map of the eastern swamp edge from Garfield to Yannathan, uniquely covers a large area but relatively small scale.

Map of Torbonarach and Red Bluff (Moore & Martin's Yallock stations)(no date)
Sketch map of the Yallock area in Gunson (1968), not to scale but informative.

Map of land subsidence of Hills (1942)
A remarkable map of early land subsidence, overlaying early contours with 1914 contours. Subsidence was due to shrinkage and loss of up to about eight feet of peat from drainage, burning, wind erosion, compaction and oxidation. The distribution of the former peat deposit is assumed to indicate the extent of the inner swamp. Points where contours lines from the two surveys converge indicate no subsidence and the edge of the deposit. Coverage is not complete so the entire deposit is not indicated. The map also appears in Hills (1975).

Soil map of Sargeant et al. (1996)
The primary source on the extent of the original peat deposit and thus the inner swamp. Map units Koo-Wee-Rup peaty clay (Ko) and Koo-Wee-Rup peaty clay with sandy ridges (Ko/sr) indicate the previous extent of peat (I. Sargeant pers. comm.). These soils are developed on alluvial deposits that pre-date the swamp. Most of the deposits were below the peat layer and now incorporate residue from the peat, hence the term 'peaty' (Hills 1942, Goudie 1942).

Hills (1942) indicates a larger area of peat deposit but Sargeant *et al.* (1996) is adopted for the inner swamp boundary due to its complete coverage. However, soil map units Ko and Ko/sr may represent a minimum estimate. The present organic or peaty content of soil is expected to be lower towards the edge of the former peat deposit where the overlying peat would have been more shallow. Marginal areas of Monomeith clay loam and Narre clay loam, which have normal amounts of organic matter, may have had shallow peat although it was 'no more than a few inches', and the transition from peaty clay to clay loam is very gradual (Goudie 1942).

Swampy riparian woodland is indicated in the mapping along the Bunyip River before it enters the inner swamp and along Yallock Creek after it leaves the inner swamp. The woodland is hypothesised or modelled in order to complete the map, all other data being sourced from existing maps. The notional width of woodland is 100 m on each side of the stream, based on the example at Bayles, while the old course of the Bunyip is unclear.

Results and Discussion

Early maps and survey plans and soil mapping are combined in Figure 1 to represent the original inner and outer boundary of the Koo-Wee-Rup Swamp. Where there are discrepancies between sources, the best source in terms of resolution is given priority. Where no data is included, along small sections of the outer boundary, no line is indicated.

The scale and accuracy of the reconstructed swamp boundary varies with the source data. Source maps such as Foot (1855) are remarkably detailed and probably accurate to within tens of metres, while other maps are at smaller scales and one is not to scale. The outer swamp boundary is a compilation of historical maps and survey plans, while the inner boundary is inferred from soil mapping and is indicative only.

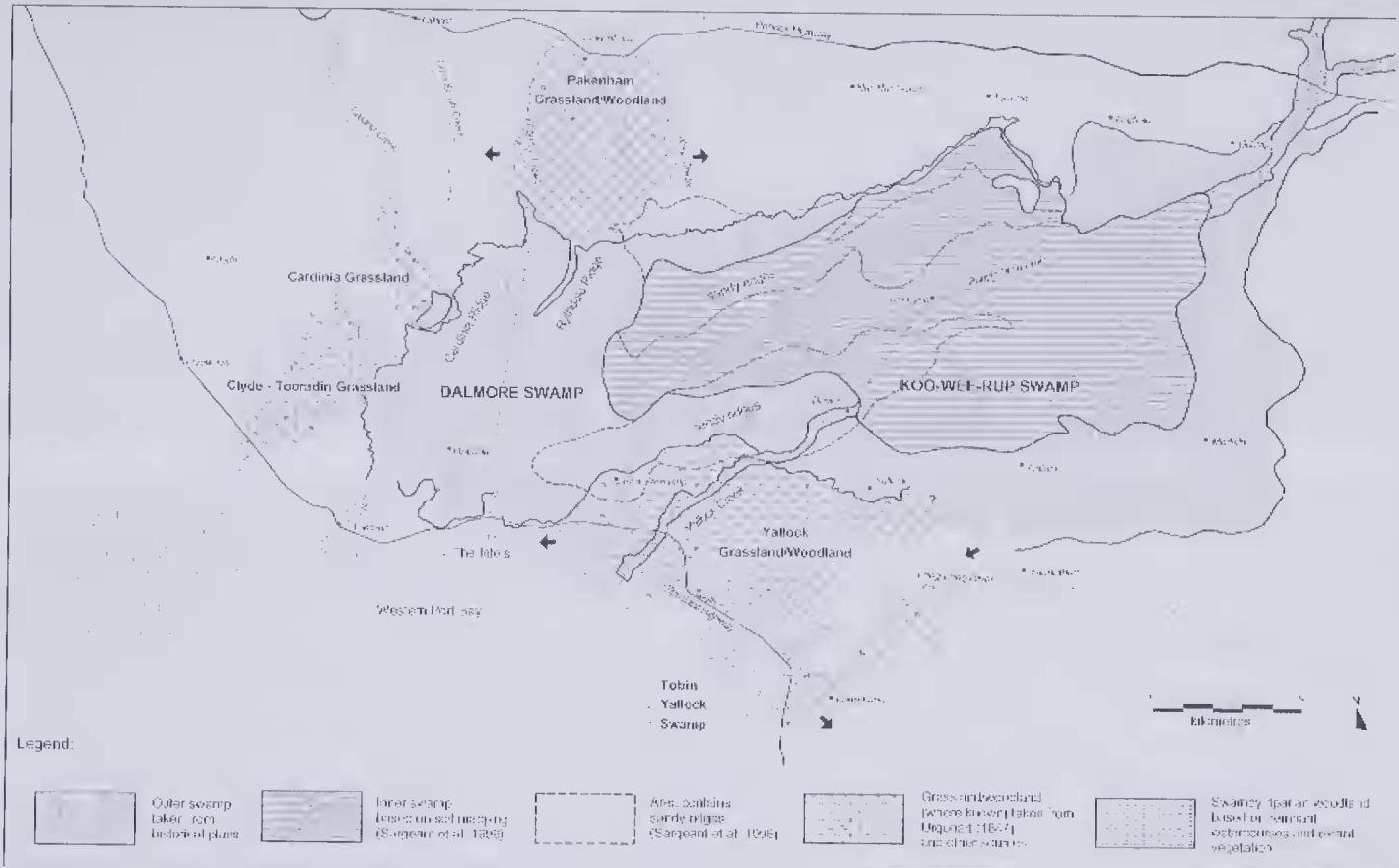

Fig. 1. Koo-Wee-Rup Swamp, reconstructed from historical plans and soil mapping.

The Koo-Wee-Rup Plain included a number of swamp complexes (Rosengren 1984):

- Koo-Wee-Rup Swamp
- Dalmore Swamp, contiguous with above, to the west
- Tobin Yallock Swamp, effectively separate from both of the above, to the south

Grasslands and woodlands were locally extensive on the margins of these swamps.

Koo-Wee-Rup Swamp

The Koo-Wee-Rup Swamp was joined with the Dalmore Swamp to form a major wetland complex with an east-west orientation. With maximum dimensions of 32 km and 14 km and over 30 000 ha in area, this was the largest swamp in Victoria.

The swamp was situated on the Koo-Wee-Rup Plain, the northern and terrestrial part of the Western Port Sunkland which is a product of block faulting (Spencer-Jones *et al.* 1975). The swamp formed after the last Ice Age in what had been an arid or semi-arid landscape. A previously dry climate is indicated by wind-formed curved ridges (lunettes) on the east side of former intermittent or dry lakes (Sargeant *et al.* 1996). With climate warming there was more rainfall and permanent flow in the Bunyip River. Permanent inundation of the inner swamp initiated peat deposition which was continuous up to the time of drainage (Hills 1942).

Sea level rise following the Ice Age truncated the swamp, greatly reducing its size. Freshwater swamp deposits outcrop along the coast as low cliffs between The Inlets and Lang Lang beach (Gell 1974; Rosengren 1984). Peat deposits also have been traced below the mudflats of Western Port Bay where they are exposed in tidal channels. Peat 0.5 m above the base of the freshwater swamp deposit on the floor of the bay was dated 12 280 to 13 480 years BP. Given the age of the peat sample and its location relative to the base of the deposit, it is likely that initial deposition began around 14–15 000 years BP. Prior to the marine incursion the Koo-Wee-Rup and Tobin Yallock Swamps extended well onto the present floor of the bay where they merged to form a large swamp for several thousand years (Miles 1976).

The outer swamp consisted primarily of closed scrub 4–6 m in height and dominated by the shrub or small tree Swamp Paperbark *Melaleuca ericifolia* (Urquhart 1847 field book). The dense scrub grew on essentially mineral clay soil rather than the deeper organic peat of the inner swamp, as *Melaleuca* requires drainage and generally does not tolerate permanent inundation. *Melaleuca* may develop a shallow peaty surface layer when frequently waterlogged or may colonise peat during dry phases where water levels are lower than normal. Some areas within the outer swamp, probably mostly localised sand ridges, supported swampy woodland of Swamp Gum *Eucalyptus ovata* with *Melaleuca* understorey, the 'Gum Scrub' of Urquhart (1847). There were 'water channels in places' (Hills 1942).

The core of the swamp was a very different environment, being relatively open and dominated by reeds and rushes. 'Two transects of the swamp made in 1868 show mainly reeds, rushes, and water where peat has now been mapped, with a small area of stunted tea-tree noted on the eastern edge' (Goudie 1942). Hills (1942) thought the reeds and rushes were probably Common Reed *Phragmites australis* and a species of *Scirpus*. The early 1868 survey, which could not be located during this study, also indicates the presence of open water.

The 13 000 ha inner swamp was essentially a massive peat bog rather than a typical swamp. With an average surface slope of 1.3 m per kilometre (Hills 1975), it could not have held one continuous standing body of water. Hills (1942) suggested it consisted of relatively small lake-like cells separated by dense growths of reeds and rushes that acted as slowly permeable barriers to the flow of surface water, while Goudie (1942) referred to 'many lagoons'. A particularly large cell or 'sheet of water' with deep peat probably existed between Cora Lynn and Catani (Goudie 1942). Groundwater moved more slowly through the peat and, in effect, the swamp was a gigantic sponge with large volumes of water slowly moving through.

The fall of the swamp decreased towards the coast, as the fall of the main drain ranges from 1.9 m/km near Bunyip to 0.6 m/km in the lower reaches (Hills 1942). This is due to the shape and size of the old alluvial fan of the Bunyip River that lay under the swamp (Goudie 1942).

Permanent inundation in the centre of the swamp resulted in the deposition of 'fibrous peat, six to ten feet deep, waterlogged for the most part' (East 1935), consisting of *Phragmites* and other vegetation not fully decomposed due to anaerobic conditions. Remains of *Phragmites*, *Typha* and *Melaleuca* were found in remnant peat by Goudie (1942). The peat also included a small amount of gravel from the catchment transported into the swamp by water currents. Up to three metres of peat had accumulated over thousands of years, and since it is resistant to erosion the massive peat deposit acted as a local base level for streams (Hills 1942, 1975).

The Koo-Wee-Rup Swamp complex was fed by about ten creeks and rivers but mainly by the Bunyip River with headwaters in the cool temperate rainforests and mountain ash forests of the Central Highlands 25 km north. Before it was channelled the Bunyip River was 'about 10 feet wide and 5 feet deep' (Catani 1901). It is not clear whether levees lined the river before it entered the inner swamp, as levees are not apparent at sites 28 and 29 of Rosengren (1984). The Lang Lang River may have connected with the swamp on its southern margin; if so it then left the swamp, crossed a short distance of grassland and entered Tobin Yallock Swamp where it dissipated. With the possible exception of the Lang Lang River, all contributing streams dissipated within the swamp complex, the outlets being separate streams.

Paperbark scrub extended back along the rivers and creeks entering the Koo-Wee-Rup Swamp, making the boundary of the swamp somewhat arbitrary in places. For example, swampy vegetation east of Bunyip along the Bunyip River and its tributaries may be considered part of the larger swamp complex but is not included in this analysis. Further historical research and map compilation are appropriate east of Bunyip in particular.

About seven creeks drained the swamp complex. The main outlet was Yallock Creek which issued from the southern edge of the inner swamp at Bayles and was essentially the lower course of the Bunyip River which entered the inner swamp in the north-east (Rosengren 1984). Natural levees lining the creek supported riparian eucalypt woodland; a valuable example is the isolated remnant woodland at Bayles. Yallock Creek and its levee woodland meandered through 3 km of scrub before leaving the outer swamp and passing through woodland and grassland to the coast. According to an early survey, Yallock Creek 'runs the greater part of the year, but towards the end of summer becomes only a chain of ponds' (Foot 1855). Low flow does not necessarily mean the inner swamp was dry as the peat may have been holding water at the time. Hovell in January 1827 found the water 'exceedingly good'.

Sand ridges were reportedly used to access the swamp for stock grazing (Hills 1942). Narrow meandering sandy ridges slightly above the present surface occur in parts of the swamp area, both inside and outside the area of the former peat deposit. There are two 'sandy complexes', in the north and south of the swamp, where sand ridges occupy more than 20% of the area, and occasional ridges occur outside these areas (Goudie 1942, Sargeant *et al.* 1996, Fig. 1). Many ridges are now modified by gravel extraction (I. Sargeant pers. comm.) but they were 0.3 to 1.5 m high and from a few metres to 20 to 40 m wide (Goudie 1942). A site with one metre ridges occurs at Pakenham South (Rosengren 1984). The ridges are probably abandoned levees and bed deposits of distributary channels of a large alluvial fan made by the Bunyip River under more arid conditions prior to formation of the swamp (Hills 1942).

From the map of early land subsidence (Hills 1942), the original surface of the sandy complexes was 0.6 to 2.1 metres higher (average 1.3 metres). It follows that many but not all of the ridges were buried under the peat, which is consistent with some ridges having a peaty loam soil indicating past coverage by peat while others do not (Goudie 1942, Sargeant *et al.* 1996). It is also likely that, along the shallow edges of the peat deposit, exposed ridges in the outer swamp extended into the inner swamp before disappearing below peat.

The sandy complexes impeded drainage and influenced the distribution and size of lagoons within the inner swamp. The southern sandy complex at Bayles may have been responsible for a 'large area of

standing water' between Cora Lynn and Catani. Similarly, the northern sandy complex blocked Ararat Creek forming a northern arm of the inner swamp (Hills 1942).

Two ridges appear on Urquhart's map: the 3 km Rythdale ridge and 2 km Cardinia ridge. Both are on the outer north-western edge of the swamp, are curved and have similar orientation (Fig. 1). They have state geomorphic significance due to their unusual landform (Rosengren 1984) and are lunettes (Sargeant *et al.* 1996). Formed by wind, and 5 to 8 m above the swamp surface in the case of Cardinia ridge, they are markedly different from the lower alluvial sand ridges. Both ridges were high ground in the swamp but they did not reach the inner swamp (the other high ground was the island at Tynong). From remnant vegetation, the crest of Rythdale ridge supported grassy woodland of Manna Gum *Eucalyptus viminalis*. The southern tip of the ridge was annotated 'point of timber' by Urquhart.

Vegetation patterns, particularly within the inner swamp, were probably intricate. The lake-like cells postulated by Hills probably would have supported a complex mosaic of reedswamp, aquatic sedgeland and aquatic herbland. Emergent sand ridges are likely to have supported vegetation ranging from stunted paperbark scrub to swampy woodland on higher sites. Sand ridges would also have determined vegetation patterns in the outer swamp due to more soil aeration and possibly higher fire frequency, generally favouring swampy woodland. They also impeded drainage resulting in local reedbeds and waterholes (1866 Yallock plan).

The close proximity of the inner and outer swamp boundaries for about 8 km between Nar Nar Goon and Garfield is of considerable interest. The area is likely to have been highly productive for the Woiwurrung, providing access to the inner swamp where fish and waterbirds would have been abundant. Tynong is said to mean 'plenty of fish' (O'Callaghan 1918). River Blackfish *Gadopsis marmoratus*, after which the swamp is named, is a valuable eating fish that presumably occurred in the swamp. Black Swan eggs may have been obtained in spring when most breeding occurs. On the south side of the swamp, the Boonwurrung could reach the inner swamp via the Yallock Creek levees as far as Bayles and also possibly in the Yallock to Yannathan area. Plant resources were presumably plentiful and included food plants such as Water-ribbons with edible tubers and Cumbungi with edible rhizomes, and Common Reed used for spear shafts, bags, baskets and necklace beads (Gott 1993).

An early sketch map of Western Port drawn by Assistant Protector of Aborigines William Thomas in 1840 depicts an area well inland of his coastal route with the label 'Pan-der-huit or Great Impassable Swamp' (Thomas in Cannon 1983). This may have been a name of the inner swamp, from buth/butj = 'grass in general' also referring to reeds and sedges (N Searlett, pers. comm.).

An island in the swamp occurred at Tynong where a low granite hill had become surrounded by swamp (Fig. 1). The description on Urquhart's map is 'island heavily timbered with gum and dense scrubs' suggesting lack of fire. At Tynong there was an abrupt sequence from grassy eucalypt woodland on granite hills to reedswamp on the plain with a fringe of *Melaleuca* and swampy woodland. The extensive view from the hills over 'impenetrable scrubs of Tea Tree, Gum Scrubs and Reeds' (Urquhart 1847) included the northern arm reedswamp and the vast inner reedswamp stretching south-west to the horizon.

A specimen of Leadbeater's Possum at Museum Victoria was collected from the hollow branch of a tree being felled at 'the edge of the Koo-Wee-Rup Swamp long before the swamp was drained, about three miles due south from Tynong railway station' (Mason in Brazenor 1932). This locality is well within the original swamp but peripheral clearing may have occurred by that time. The hollow-bearing tree may have been a Swamp Gum on a sand ridge. The location suggests sand ridges outcropped above the peat south-west of the Tynong island. A sand ridge in the vicinity mapped by Rosengren (1984) may have been the collection site.

Magpie Goose is recorded from Koo-Wee-Rup and the swamp would presumably have supported large numbers of this bird which was locally abundant in south-

east Australia. From the habitat preferences and behaviour of the species in northern Australia (Nye 2004), the inner swamp would have provided nesting habitat, the outer swamp roosting habitat in trees and shrubs, and the adjacent floodplain grasslands foraging habitat. The swamp area thus provided all necessary habitats for the species as well as drought refuge.

As with many swamps in Australia, Kuwirap was said to be inhabited by a large black monstrous amphibious creature with a harsh call, known as the bunyip. The Woiwurring called the creature Banib hence the place name Bunyip, while the Boonwurrung called it Tooroodun hence the name Tooradin (Database of Aboriginal Placenames of Victoria 2002).

'On the Western Port plains, there is a basin of water—never dry, even in the hottest summers—which is called Toor-roo-dun, because the Bun-yip lives in that water' (Smyth 1878), which suggests Toor-roo-dun was also a name of the inner swamp. Reputed to devour human beings, Toor-roo-dun was said to inhabit the deep waters and the thick mud beneath the waters of the swamp and to have a head and neck like an emu (Smyth 1878).

No bunyip story in Australia is recorded in detail. The story may relate to seals which sometimes visit freshwater rivers and swamps, as bunyips reported by early Europeans were apparently vagrant seals, or even to extinct megafauna such as *Diprotodon* (Flett 1999). However, the swamp formed after the megafaunal extinction and it is implausible that the coastal Boonwurrung would not have recognised seals even outside their usual habitat.

Draining and clearing the Koo-Wee-Rup and Tobin Yallock Swamps rapidly led to deep incision and channel erosion of the feeder streams upstream, due to lowering of the local base level. By 1916 the Bunyip Main Drain had deposited a layer of sediment two feet thick 1½ miles out to sea (East 1935). Bunyip Main Drain and Lang Lang River (Drain) remain by far the largest contributors of suspended sediment to Western Port Bay (Wallbrink *et al.* 2003). The slow recovery of seagrass cover since the decline of the 1970s (Ball and Blake 2001) and declining fisheries in the bay (DPI 2004) may be affected by the resulting high turbidity.

Dalmore Swamp

Before it was drained and cleared, Dalmore Swamp was fed mainly by Cardinia Creek and was known for its dense, almost impassable scrub (Goudie 1942). It occurred on mineral clay soil rather than the deep peat of the inner Koo-Wee-Rup Swamp. A continuous line of 'impenetrable scrubs' was mapped by Urquhart (1847) along the north edge of the 'Great Swamp' then consisting of both swamps in combination. Dalmore Swamp was effectively joined with the Koo-Wee-Rup Swamp, forming a western extension of the outer swamp. The swamp was drained by five tidal creeks, four at The Inlets and Sawtell Creek at Tooradin.

The central area has a layer of decomposed peat approximately 75–85 cm below the surface which may reach a thickness of 60 cm (Goudie 1942). The peat seam is valuable in market gardening due to the internal soil drainage it provides (Sargeant *et al.* 1996), the overlying black clay preventing it from being lost. Remains of club-sedge *Bolboschoenus* have been found in the peat (S Seymour pers. comm.), consistent with Goudie who identified seeds of '*Scirpus* and *Lepidosperma*' in the peat (*Bolboschoenus* was previously *Scirpus*).

The centre of the Dalmore Swamp once may have been an arm of the inner swamp until local geological uplift reduced the catchment size and stream flow of the western feeder streams, ending peat formation and leading to deposition of the overlying Dalmore clay (Hills 1942). However, soil maps indicate the Dalmore peat was not connected with the inner swamp peat (Goudie 1942, Sargeant *et al.* 1996), suggesting the past existence of two inner swamps.

Tobin Yallock Swamp

The former extensive Tobin Yallock Swamp was south of the Yallock grasslands and was fed mainly by the Lang Lang River. It consisted largely of *Melaleuca* scrub fanning out to form a 6 km length of the north-east coast of Western Port Bay. With no mangrove or salt marsh fringe and no beach, this shoreline *Melaleuca* scrub was highly unusual in Victoria.

The shore was probably cliffed and receding when mapped by Smythe, the low two metre cliff consisting of exposed freshwater swamp peat and clay. There was no single outlet, water issuing from the swamp via 'numerous rills of fresh water continually running' (Smythe 1843). 'It is possible that floodwaters spilling out in this way produced the crenulate shoreline, with waterfalls scouring out each cove' (Bird and Barson 1975).

Gum Scrub Creek drained the outer Koo-Wee-Rup Swamp at Caldermeade and was vegetated by 'Tea Tree Swamp'; it then entered Tobin Yallock Swamp and dissipated. The scrub from the two swamps almost connected via a tenuous link where the first European 'road' was situated (Smythe 1843), almost certainly following the Aboriginal path between the swamps.

A valuable 1887 Lands Department plan of Tobin Yallock Swamp, showing scrub along the coast and a mosaic of scrub and grassland further inland, is in Key (1967). The grassland is described as 'coarse pasture land very wet in winter' and 'very good pasture land'.

Further research and mapping would be worthwhile to better define the edges of the Tobin Yallock and Koo-Wee-Rup Swamps and the largely open area between them. Smythe's (1843) description of some sites as 'Tea Tree Swamp' is not consistent with surveys of Foot (1855) and Callanan (1866) who maps belts of 'Tea Tree' within 'very course pasture land timbered [with] gums & very wet in winter'. Smythe's is an exploratory survey but fire or clearing may have fragmented the scrub near Toorbinarruk Station between surveys.

Associated grasslands

The extensive grassland or open woodland on the floodplain of Yallock Creek, between the Koo-Wee-Rup and Tobin Yallock Swamps, was no doubt familiar to the Yallock balug clan. However, explorer Samuel Wright was the first European to see it, in 1826. He described it as follows (quoted in Gunson 1968):

> in point of quality ... equal to any he ever saw in the Colony, it appeared like beautiful meadows in England, very thin of timber, grass excellent

Soon after, explorer William Hovell (1827) described the same area:

> one mile from the tent [mouth of Yallock Creek], I came to a fine open level country, very thinly covered with trees, soil of a good quality, and the grass long and fresh ... the only objection to it is that I think it lies too flat to be perfectly dry in rainy seasons

The area south of Yallock Creek seen by Hovell is in Monomeith, which is an Aboriginal term meaning 'pleasant, good, pure' (Massola 1968), 'good and beautiful' (Gunson 1968) or 'pleasant, agreeable' (Blake 1977). This may have been a reference to the open and productive terrain compared to dense swamp scrub, or a reference to water quality. It is noted that 'monomeeth poath' means 'a grassy plain, a lawn' (Bunce in Smyth 1878).

'It was this natural grassland which made the Yallock area, just south of the swamp, so attractive to early squatters' (Key 1967). Smythe (1843) mapped swamp scrub and acacia woodland forming a mosaic in the local area. The description of the relatively open country between belts of 'Tea Tree Swamp' is 'Rich black soil wooded with Lightwood' and 'good grass'. Mapping of the open areas includes many series of non-random dots that may represent trees thus depicting a mosaic of grassland and acacia woodland.

On its western side, the Great Swamp had an adjacent 'open grassy plain' at Cardinia where Cardinia Creek entered the swamp (Urquhart 1847). Another 'open grassy plain' north of Tooradin about 5 by 2–3 km in size (Cook and Yugovic 2003) was described by Hovell (1827):

> I came to another open space, quite clear of trees for several miles square, but so perfectly flat that the water appears to have no possibility of draining off, consequently after rain the ground must be some time before it can absorb the whole, but at this time we could not get a drop to moisten our lips, which would have been very acceptable from it being so very hot, and which we so much required, having come upon a native path, which led in the direction I wanted to go, I kept upon it in hopes that it would lead to water

William Blandowski crossed the grassy plains during his scientific exploration of Western Port in 1855. He described it thus (1855):

> Between Lisle's station [Tooradin] and the inlets, the land is swampy, and luxuriantly

> covered with excellent grass, well adapted for fattening cattle. . . Between Lisle's and Cuthbert's station [The Gurdies] the country consists of magnificent pasture grounds, the horse having to walk through thick kangaroo grass, reaching up to the girths.

Grassland and acacia woodland, essentially the same plant community, were locally extensive on alluvial plains outside the wall of *Melaleuca* scrub that defined the edges of the Great Swamp and Tobin Yallock Swamp. The major grass was moisture-demanding Common Tussock-grass *Poa labillardierei*. Also present, usually on slightly drier sites, was Kangaroo Grass *Themeda triandra*, the dominant grass of dry basalt grasslands in western Victoria. The grassland was rich in flora and fauna (Cook and Yugovic 2003) including the Aboriginal staple Murnong (Yam Daisy) *Microseris* sp. which was probably common. Southern Brown Bandicoot was probably common in less flooded areas and still occurs in grassland remnants.

Blackwood *Acacia melanoxylon* (then called Lightwood) and to a lesser extent Swamp Gum were the major trees in this grassy environment due to their resilience to flood, drought and fire. Blackwood's suckering habit enables it to survive fire. Some individuals would reach tree size and avoid grass fires, forming a woodland. The area is just beyond the range of River Red-gum *Eucalyptus camaldulensis* probably due to high rainfall. Acacia woodland on flood plains, previously a distinctive part of the landscape, is now very rare or extinct as an ecosystem. However Blackwood remains widespread, mainly on road and rail reserves.

The outer swamp boundary has no clear relationship with soil type (Sargeant *et al.* 1996) as the same soils occur on both sides of the surveyed boundary. Since *Melaleuca* tends to occupy former grassland sites today, we suggest that Koories were burning back the edges of the swamps for access and hunter gathering. All the early European explorers of Western Port noted that large areas of land were burnt (Gaughwin 1981). William Thomas noted that since the neighbouring Yowengarra clan was defunct their country had become scrubby because it was not being periodically burned (Clark 1990). Urquhart's field book refers to frequent burning reducing the *Melaleuca* on open plains 'producing good grass'. 'Many layers of burnt tea tree branches were found when the swamp was drained' (Roberts 1985). As dry peat is flammable, accumulation of the massive peat deposit in the presence of the Aboriginal fire regime presumably was due to water in the inner swamp preventing major peat fires.

Melaleuca ericifolia reproduces by root-suckering and seedlings, enabling rapid spread under suitable conditions. The Koories were probably advantaged by a natural weakness or tolerance limit of *Melaleuca*: while it was flood tolerant it was not tolerant of the high fire frequency on the swamp margin associated with drier soils and more flammable vegetation. *Melaleuca* can regenerate after fire but may be greatly reduced in cover, so the position of the swamp boundary is likely to have been a long-term response to repeated fire.

Drainage patterns indicate the floodplain grasslands and woodlands occurred on slightly higher and therefore less flooded land than the swamp. It follows the soils were more prone to dry out and crack in summer but it is unlikely soil factors alone would have controlled *Melaleuca*. A combination of soil and fire factors may have operated to confine the scrub. Both the inner and outer swamp boundaries may have been relatively stable over time, or dynamic and responsive to change in factors such as rainfall, evaporation, flooding and fire.

Fire may have been particularly important to the Boonwurrung for access purposes. Aboriginal burning is likely to have maintained the 18 km open space corridor between Tooradin and Lang Lang and the effective separation of the Koo-Wee-Rup and Tobin Yallock Swamps. The Yallock balug clan were most likely managing their grassy open landscape by regular burning, without which the land would have become dense and effectively uninhabitable scrub. In doing so they maximised both food production and biodiversity.

At The Inlets, the grassland strip passing between the inland paperbark scrub and the coastal samphire and mangrove scrub was less than 300 m wide and probably

formed a vital corridor in the middle of the tribal range. Four tidal creeks draining the Dalmore Swamp and the terminal western arm of the inner swamp were in close proximity. Part of the area is described as 'good grass pasture land' on the 1866 survey plan. Remnant vegetation includes grasslands associated with various salinity regimes. Non-saline sites are mostly dominated by Kangaroo Grass, brackish sites are dominated by Common Tussock-grass (Fig. 2), while relatively saline sites beside salt marsh are dominated by Coast Tussock-grass *Poa poiformis*.

Despite the previously locally extensive occurrence of periodically wet grasslands on flood plains adjacent to swamps, recognition of this distinctive ecosystem occurred only in the 1990s (SAC 1994), reflecting early modification and loss of the grasslands before recording.

The now rare plains grassland may be predicted to occur on alluvial 'black soil' outside the margins of former swamps on the Gippsland plain. The eastern side the Great Swamp may have had little or no grassland, such as in the north-east area where foothills of the ranges formed an edge with the swamp (Garfield to Bunyip). Here *Melaleuca* evidently extended to the break of slope. However, the rail survey map with this evidence was compiled after cessation of the Aboriginal fire regime, so *Melaleuca* may have spread onto grassland.

This knowledge of the swamp boundary has been useful in locating and recognising several significant remnants of grassland such as the Clyde-Tooradin grassland (Cook and Yugovic 2003) and the Yallock grassland seen by Samuel Wright 180 years ago (Fig. 3). Similarly, extremely rare remnants of outer swamp scrub have been found, including an example with the original swamp boundary beside brackish sedgeland at The Inlets estuary.

Conclusions

The Koo-Wee-Rup Swamp was a unique ecosystem with distinct zonation formed by inner and outer swamps. The inner swamp was a permanently inundated reed and rush swamp on deep peat with localised emergent sand ridges. It is likely to have included a descending series of lake-like cells or lagoons separated by dense belts of vegetation, resulting in multiple internal water levels rather than the single water level of most swamps. The fringing outer swamp was subject to frequent flooding and supported dense *Melaleuca*, giving an impression that the scrub occurred throughout. Adjacent grasslands and grassy woodlands were occasionally flooded and were locally extensive beyond the generally sharp swamp boundary.

We suggest the inner swamp boundary was primarily flood controlled while the outer swamp boundary was primarily fire controlled on the plain and topographically controlled by hills to the east. Aboriginal burning maintained the adjacent grasslands and woodlands but had little or no influence on the core of the swamp where permanent water prevented major peat fires.

Despite the major environmental change, some of the wetland flora and fauna of the original swamp live in, visit or pass through the area today, the many drains and pastures providing modified habitat. Swamp Paperbark and Common Reed are conspicuous along many drains. In addition, some flora and fauna from the forest catchment of the Bunyip River such as Silver Wattle *Acacia dealbata* have colonised the banks of the Bunyip Main Drain.

Further historical research and field investigation would resolve these wetland and grassland ecosystems more clearly, this analysis forming a basis for further study. An understanding of historical and extant ecosystems and landscapes provides the basis for informed land management. Rare examples of scrub and grassland remain, all in need of management.

This study shows how careful interpretation of small remnants, in combination with examination of archival records, can further our knowledge of highly fragmented vegetation types such as native grasslands. It also demonstrates that existing vegetation on roads and drains may be misleading as to pre-European vegetation patterns. Similar studies may provide useful insights in other heavily cleared regions.

Fig. 2. Native grassland 200 m from the swamp edge (not in photo), The Inlets.

Fig. 3. Native grassland on the floodplain of Yalloek Creek, Monomeith.

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